

MR-based keyhole SPECT for small animal imaging.

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Public Summary:

The rationale for multi-modality imaging is to integrate the strengths of different imaging technologies while reducing the shortcomings of an individual modality. The work presented here proposes a limited-field-of-view (LFOV) SPECT reconstruction technique that can be implemented on a multi-modality MR/SPECT system that can be used to obtain simultaneous MRI and SPECT images for small animal imaging. The reason for using a combined MR/SPECT system in this work is to eliminate any possible misregistration between the two sets of images when MR images are used as a priori information for SPECT. In nuclear imaging the target area is usually smaller than the entire object; thus, focusing the detector on the LFOV results in various advantages including the use of a smaller nuclear detector (less cost), smaller reconstruction region (faster reconstruction) and higher spatial resolution when used in conjunction with pinhole collimators with magnification. The MR/SPECT system can be used to choose a region of interest (ROI) for SPECT. A priori information obtained by the full field-of-view (FOV) MRI combined with the preliminary SPECT image can be used to reduce the dimensions of the SPECT reconstruction by limiting the computation to the smaller FOV while reducing artifacts resulting from the truncated data. Since the technique is based on SPECT imaging within the LFOV it will be called the keyhole SPECT (K-SPECT) method. At first MRI images of the entire object using a larger FOV are obtained to determine the location of the ROI covering the target organ. Once the ROI is determined, the animal is moved inside the radiofrequency (rf) coil to bring the target area inside the LFOV and then simultaneous MRI and SPECT are performed. The spatial resolution of the SPECT image is improved by employing a pinhole collimator with magnification >1 by having carefully calculated acceptance angles for each pinhole to avoid multiplexing. In our design all the pinholes are focused to the center of the LFOV. K-SPECT reconstruction is accomplished by generating an adaptive weighting matrix using a priori information obtained by simultaneously acquired MR images and the radioactivity distribution obtained from the ROI region of the SPECT image that is reconstructed without any a priori input. Preliminary results using simulations with numerical phantoms show that the image resolution of the SPECT image within the LFOV is improved while minimizing artifacts arising from parts of the object outside the LFOV due to the chosen magnification and the new reconstruction technique. The root-mean-square-error (RMSE) in the out-of-field artifacts was reduced by 60% for spherical phantoms using the K-SPECT reconstruction technique and by 48.5-52.6% for the heart in the case with the MOBY phantom. The K-SPECT reconstruction technique significantly improved the spatial resolution and quantification while reducing artifacts from the contributions outside the LFOV as well as reducing the dimension of the reconstruction matrix.

Scientific Abstract:

The rationale for multi-modality imaging is to integrate the strengths of different imaging technologies while reducing the shortcomings of an individual modality. The work presented here proposes a limited-field-of-view (LFOV) SPECT reconstruction technique that can be implemented on a multi-modality MR/SPECT system that can be used to obtain simultaneous MRI and SPECT images for small animal imaging. The reason for using a combined MR/SPECT system in this work is to eliminate any possible misregistration between the two sets of images when MR images are used as a priori information for SPECT. In nuclear imaging the target area is usually smaller than the entire object; thus, focusing the detector on the LFOV results in various advantages including the use of a smaller nuclear detector (less cost), smaller reconstruction region (faster reconstruction) and higher spatial resolution when used in conjunction with pinhole collimators with magnification. The MR/SPECT system can be used to choose a region of interest (ROI) for SPECT. A priori information obtained by the full field-of-view (FOV) MRI combined with the preliminary SPECT image can be used to reduce the dimensions of the SPECT reconstruction by limiting the computation to the smaller FOV while reducing artifacts resulting from the truncated data. Since the technique is based on SPECT imaging within the LFOV it will be called the keyhole SPECT (K-SPECT) method. At first MRI images of the entire object using a larger FOV are obtained to determine the location of the ROI covering the target organ. Once the ROI is determined, the animal is moved inside the radiofrequency (rf) coil to bring the target area inside the LFOV and then simultaneous MRI

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